5.0 FUTURE CONDITIONS

5.1 Population Development

Between the spring of 2003 and summer of 2004, staff from the City's consultant (Roth Hill) and the County developed an approach to forecast the City's population and wastewater design flows. The results of this work were incorporated into the 2004 Comprehensive Sewer Plan[179] and TM No. 2.[180] These estimates were based on an analysis of the population distributions identified within sewer basins and took into account residential populations, employment, industrial flows, schools, and parks. Population projections were based on the assumption that the new sewer system would be operational in the year 2007 and that growth rates would be modest until that time. It was further assumed that the compound annual growth rate would be one percent for the period from the 2000 base year to year 2007. After completion of the entire sewer system, growth rates would increase to a compound rate of five percent until the date estimated for the phased completion of sewer system throughout the entire city (2012). After 2012, a more modest growth rate of three percent would be sustained until the calculated build-out population was reached. Roth Hill determined the build-out population to be 3,871 persons, based on an analysis of the zoning for each proposed sewer basin. According to this analysis, the saturation population would be reached in 2017. The detailed methodologies used for projecting population increases within the City are documented in the 2004 Comprehensive Sewer Plan.[181]

Population projections are shown in Table 5.1. These estimates will be used for the projection of flow and pollutant loadings for the WWTF. Though Roth Hill estimated that the residential population saturation level would be reached by 2017 and that there would be no further increase in population after that year, it was estimated that employment would not reach the employment saturation level until sometime between 2023 and 2050.

Table 5.1 Population Projections for the City
Carnation Wastewater Treatment Facility
King County Department of Natural Resources and Parks

Population	Milestone and Year			
	Startup 2007	Full Sewer[a] 2012	Residential Saturation[b] 2017	Design Year 2030
Residential	2,185	3,816	3,871	3,871
Commercial	634	809	1,254	2,175
Industrial (Remlinger Farms)	880	880	880	880
Middle school	757	1,323	1,342	1,342
High school	725	1,266	1,284	1,284
Elementary school	419	732	743	743
Park	60	60	60	60

a. End of the anticipated rapid increase in population (5% annual growth rate until the buildout density is reached) after the vacuum sewers are available.

b. The residential saturation was determined based on the buildout density of the residentially zoned land within the UGA.

Source: Roth Hill Engineering Partners, LLC, *City of Carnation 2004 Sewer Facilities Plan*, *City Review Draft,* September 2004.

5.2 Flow Development Methodology

5.2.1 Average Annual Flow

Table 5.2 summarizes the unit flow rates adopted for each population category . All of these unit flow rates are comparable to the rates presented in the *Criteria for Sewage Works Design Manual* (Orange Book),[182] with the exception of the residential per capita rate. The Orange Book provides a recommended value of 100 gallons per day (gpd) for each resident in the State of Washington. This value includes a standard allowance for inflow and infiltration (I/I) to the sewers. Based on previous studies, the City has decided to implement a vacuum-based sewer collection system. The planned design of the vacuum-based system will reduce I/I to negligible volumes. The City estimated an average historical residential per capita water demand of 56 gpd, based on an analysis of the City's metered residential water use in 2000, 2001, and 2002.

Table 5.2 Unit Rates for Wastewater Flow Carnation Wastewater Treatment Facility King County Department of Natural Resources and Parks		
Facility Type	**Design Unit**	**Flow (gpd)**
Residential	Per person	65
Commercial	Per employee	30
Industrial	Per employee	30
Elementary school	Per person per 8 hours	10
Middle school	Per person per 8 hours	16
New high school	Per person per 8 hours	10
Park	Per developed campsite	100
gpd = gallons per day		

The historical water usage includes a large percentage of "unaccounted for" water consumption in the City. Overall, the City's non-revenue water (unaccounted for and unmetered water) is estimated to be 40 percent of water produced. Typically, 10 to 20 percent of water production is not accounted for within a water system.[183] Of the 40 percent non-revenue water within the City, an estimated 15 percent is unmetered water.[184] The unmetered amount is therefore equivalent to six percent of the City's total water production. Although no information on the composition of the unmetered demand within the City is available, municipal uses such as for streets, medians, and parks dominate the unmetered usage category in other cities. For planning purposes, the current engineering design for residential wastewater flow allows for a per capita rate of 65 gpd, which includes an allowance of 15 percent for unexplained water entering the sewer system, water meter inaccuracies, and a small I/I contingency. This design rate does not account for any potential future per capita demand reductions based on more efficient appliances. See Chapter 7 for a discussion of future demand reductions.

Residential water demand accounts for approximately 70 percent of the historical total indoor water demand, as illustrated in Figure 5.1. Therefore, the majority of the City's wastewater flow will be derived from homes. This flow is not anticipated to contain large quantities of commercial or industrial waste. Major commercial and industrial contributors identified include QFC, Custom Concrete, and Remlinger Farms.

5.2.2 Inflow and Infiltration

Inflow and infiltration are terms used to describe extraneous water flows into a sewer system. Inflow refers to flows that result from stormwater runoff through a direct connection to the sewer system, which can cause a rapid increase in flow. Inflow access points include manhole covers, roof leaders, and yard drains. Specifically, infiltration refers to water that enters a sewer system from the ground through defective interceptors, pipe joints,

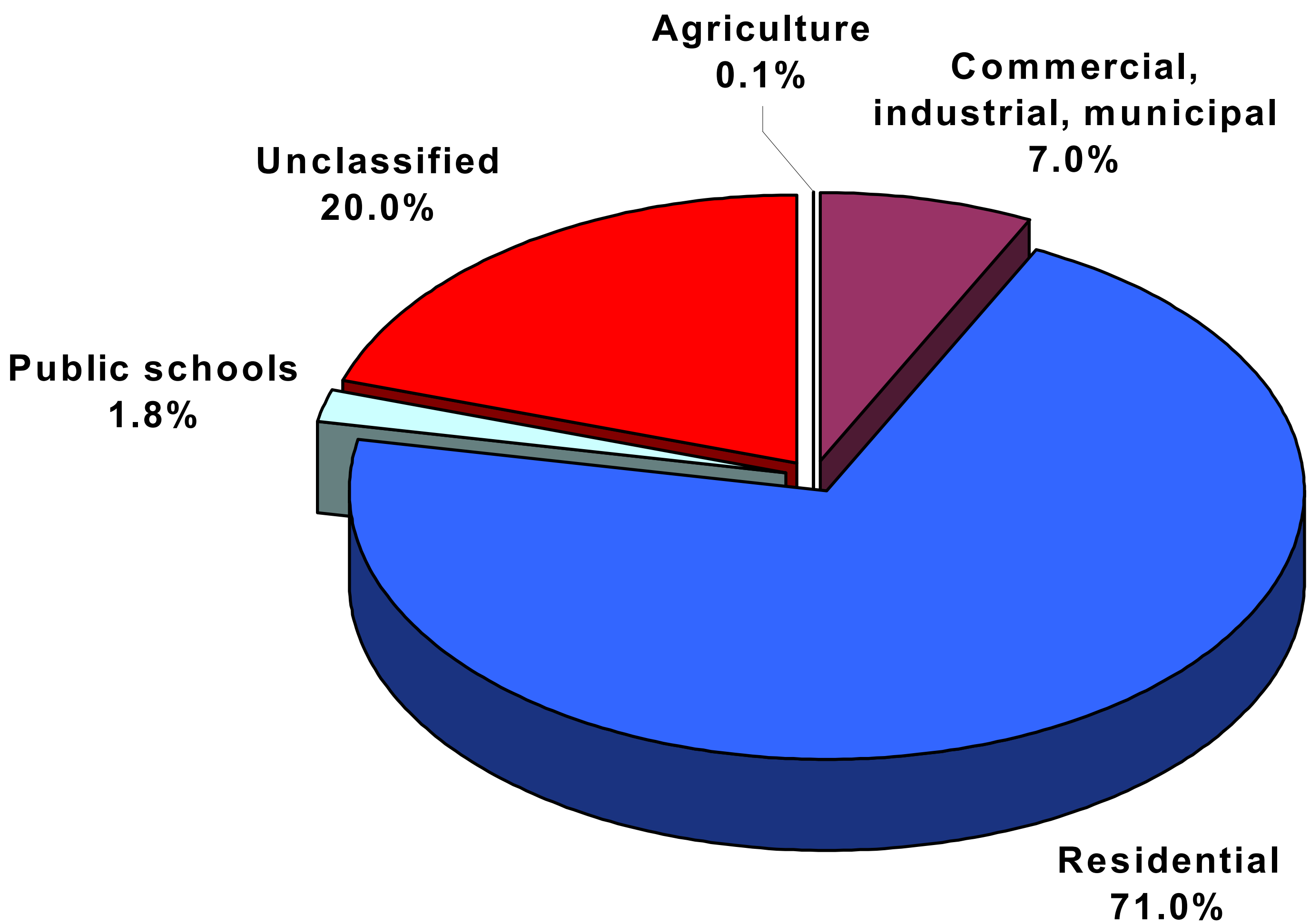

Figure 5.1

2002 City Potable Indoor/Non-seasonal Water Use
Carnation Wastewater Treatment Facility
King County Department of Natural Resources and Parks

connections, or manhole walls. I/I is typically included as part of projecting wastewater flows. The 2000 Comprehensive Sewer and Facilities Plan[185] assumed there would be no I/I contribution with the use of a grinder pump-based collection system (the system recommended in the plan). Subsequent to the completion of the 2000 Comprehensive Sewer and Facilities Plan, the City decided to implement a vacuum-based sewer collection system. Although the vacuum-based system will include several gravity side sewers, the City presently assumes that I/I will account for a negligible amount of flow.[186]

5.2.3 Peaking Factors

To establish the maximum monthly flow (MMF), maximum daily flow (MDF), and peak hourly flow (PHF) projections for the CWWTF, the following sources were consulted:

- Orange Book[187]
- City's monthly water consumption data (January 2000 to December 2002)
- Hourly operating data from Ocean Shores, Washington (January to December 2003)

Ocean Shores had the first and, to date, the only large vacuum-based sewer collection system in the State of Washington. However, the City's demographic profile is different than that of Ocean Shores. The City is a suburban/rural residential community with a stable seasonal population, whereas Ocean Shores has a large proportion of vacation homes. Hence, Ocean Shores would be expected to have peak flow occurrences higher than the City because of the seasonal and part-time nature of the residential community. Detailed discussions of the data from each source are provided in TM No. 2.[188] Table 5.3 provides a summary of the peaking factors determined based on the data and the proposed factors for the CWWTF design.

Table 5.3 Comparisons of Peaking Factors
Carnation Wastewater Treatment Facility
King County Department of Natural Resources and Parks

Parameter	Peaking Factor		
	City Water Records	Ocean Shores	Proposed for Design
Minimum daily flow	0.98	0.71	0.8
Average annual flow	1.00	1.00	1.0
Maximum monthly flow	1.14	1.63	1.3
Maximum daily flow	1.41	2.32	2.1
Peak hourly flow			
Residential	1.71	2.60	3.0
Schools	1.71	2.60	6.0

Projections using the City's winter water records from 2000 to 2002 result in a maximum monthly peaking factor of 1.14, while the Ocean Shores data produce a higher factor of 1.63. If no I/I is considered, the wastewater maximum month peaking factor for the City should be similar to the potable water maximum month peaking factor. In addition, given the highly seasonal nature of the Ocean Shores population, the lower peaking factor is more realistic for the City, even if a small fraction of I/I is considered. Therefore, it is proposed that the design assume a maximum monthly peaking factor of 1.3, to account for a conservative flow fraction for inflow and infiltration and serve as an intermediate factor between the City's water records and Ocean Shores data. The peaking factor is not atypical of this community size. For example, the City of Birch Bay, WA received an average flow of 0.66 MGD with a 1.24 maximum month wastewater peaking factor between 2001 and 2005. The maximum daily peaking factors from the City's winter water records and Ocean Shores data are 1.41 and 2.32, respectively. An intermediate factor of 2.1 is proposed for design, based on the diurnal flow curve for Ocean Shores and the overall peak flow developed for the City.

5.3 Wastewater Design Loads

The Orange Book provides recommended BOD and TSS design loads for sewage collection systems. These concentrations are consistent with those for the wastewater influent to the County's South Treatment Plant, which is assumed to serve a population with a residential makeup that is similar to that of the City. The following design average annual load (AAL) projections for residential wastewater flows to the CWWTF, have been assumed:

- BOD = 0.2 lb BOD / equivalent population / day
- TSS = 0.2 lb TSS / equivalent population / day
- TKN = 0.032 lb N / equivalent population / day
- Total phosphorus = 0.005 lb P / equivalent population / day

The following AAL projections for wastewater from commercial, industrial, and middle/high school sources have been assumed:

- BOD = 0.04 lb BOD / equivalent population / day
- TSS = 0.04 lb TSS / equivalent population / day
- TKN = 0.006 lb N / equivalent population / day
- Total phosphorus = 0.001 lb P / equivalent population / day

The following AAL projections for wastewater from the elementary school (without showers) have been assumed:

- BOD = 0.025 lb BOD / equivalent population / day
- TSS = 0.025 lb TSS / equivalent population / day
- TKN = 0.004 lb N / equivalent population / day
- Total phosphorus = 0.001 lb P / equivalent population / day

The following AAL projections for wastewater from the Tolt MacDonald Park have been assumed:

- BOD = 0.10 lb BOD / equivalent population / day
- TSS = 0.10 lb TSS / equivalent population / day
- Total Kjeldahl nitrogen (TKN) = 0.016 lb N / equivalent population / day
- Total phosphorus = 0.003 lb P / equivalent population / day

For unit process sizing for the CWWTF, projections have been developed for average annual and maximum monthly loads (MMLs) for the various wastewater constituents. Due to a lack of data on historical wastewater flows and loads generated within the City service area, MML projections have been based on an assumed peaking factor. An MML peaking factor of 1.3 was applied to the AAL to estimate the MML matching the peaking flow factor. This peaking factor value is consistent with Carollo's previous experience with wastewater utilities, as well as the existing and projected service area characteristics of the City. With little I/I in the system, it is reasonable to assume that MMF and MML could occur simultaneously. Table 5.4 summarizes the flow and load projections for the CWWTF. Projections are shown for major milestones through the 2030 design year.

Although the overall pollutant loading increases as the facility approaches design year, the anticipated pollutant concentration decreases after 2017. Based on the methodology used for projecting the City's population increase, residential build out is anticipated to occur by 2017.[189] Meanwhile, the continued growth of commercial establishments increases the overall flow and loading input to the facility. With lower pollutant concentrations and an increased fraction of flow stemming from commercial wastewater sources, decreasing influent concentration trends are anticipated to occur after 2017.

Table 5.4 Flow and Load Projections
Carnation Wastewater Treatment Facility
King County Department of Natural Resources and Parks

Parameter	Load Projections by Milestone and Year: Startup 2007	Full Sewer 2012	Residential Saturation 2017	Design Year 2030
Flow, mgd				
Average annual	0.21	0.32	0.34	0.37
Maximum monthly	0.27	0.42	0.44	0.48
Maximum daily	0.43	0.67	0.71	0.77
Peak hourly[a]	0.63	0.72	1.29	1.4
BOD, lb/day				
Average annual load	538	923	954	991
Maximum monthly load	700	1,200	1,240	1,288
Maximum daily load	915	1,570	1,622	1,684
BOD, mg/L				
Average annual load	314	340	334	321
Maximum monthly load	409	442	434	417
Maximum daily load	534	579	568	546
TSS, lb/day				
Average annual load	538	923	954	991
Maximum monthly load	700	1,200	1,240	1,288
Maximum daily load	915	1,570	1,622	1,684
TSS, mg/L				
Average annual load	314	340	334	321
Maximum monthly load	409	442	434	417
Maximum daily load	534	579	568	546
TKN, lb/day				
Average annual load	86	148	153	159
Maximum monthly load	112	192	198	206
Maximum daily load	146	251	259	269
TKN, mg/L				
Average annual load	50	54	53	51
Maximum monthly load	65	71	69	67
Maximum daily load	86	93	91	87
Total P, lb/day				
Average annual load	13	23	24	25
Maximum monthly load	17	30	31	32
Maximum daily load	40	69	72	74
Total P, mg/L				
Average annual load	8	9	8	8
Maximum monthly load	10	11	11	10
Maximum daily load	24	26	25	24

BOD = biochemical oxygen demand

TSS = total suspended solids

TKN = total Kjeldahl nitrogen

P = phosphorus

a. See Chapter 7 for a discussion on satisfying the peak-hour facility capacity through increased MBR flux rates and MBR feed pump wet well equalization.

Notes

[179] Roth Hill Engineering Partners, LLC, *City of Carnation 2004 Comprehensive Sewer Plan*, October 2004.
[180] Carollo Engineers, *Technical Memorandum No. 2 - Population, Flow, and Loads*, 2004.
[181] Roth Hill Engineering Partners, LLC, *City of Carnation 2004 Comprehensive Sewer Plan*, October 2004.
[182] Washington State Department of Ecology, *Criteria for Sewage Works Design Manual*, 1998.
[183] National Drinking Water Clearing House, *Water Conservation Measures Fact Sheet*, 1998.
[184] Roth Hill Engineering Partners, LLC, *City of Carnation 2004 Comprehensive Sewer Plan*, October 2004.
[185] American Engineering Corporation, *Draft City of Carnation Comprehensive Sewer and Facilities Plan*, May 2000.
[186] Roth Hill Engineering Partners, LLC, *City of Carnation 2004 Sewer Facilities Plan*, *City Review Draft,* September 2004.
[187] Washington State Department of Ecology, *Criteria for Sewage Works Design Manual*, 1998.
[188] Carollo Engineers, *Technical Memorandum No. 2 - Population, Flow, and Loads*, 2004.
[189] Roth Hill Engineering Partners, LLC, *City of Carnation 2004 Comprehensive Sewer Plan*, October 2004.